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PRODUCTIVITY AND PROFITABILITY OF FENUGREEK (*TRIGONELLA FOENUM-GRAECUM* L.) AS INFLUENCED BY BIO-FERTILIZERS AND PLANT GROWTH REGULATORS

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ABSTRACT

The experiment comprising four levels of bio- fertilizers (no inoculation, *Rhizobium*, PSB and *Rhizobium*+ PSB) and four levels of plant growth regulators (GA_3 50 and 100 ppm and NAA 10 and 20 ppm) and water were sprayed thrice during the crop growth period. These treatments were evaluated under factorial random block design with three replications. The highest plant height (89.91cm) and dry matter accumulation per plant at all the growth stages as well as number of branches per plant (6.68) and yield attributes, seed yield (17.43q /ha), net return (Rs. 22214.27/ha) and BCR(2.71) in fenugreek was obtained highest with dual inoculation of seed with *Rhizobium*+ PSB. The growth parameters, yield components and seed yield showed positive response to foliar application of plant growth regulators. Foliar application of plant growth regulators significantly influenced the plant growth parameters, yield attributes, yield, net returns and BCR.Foliar application of 20 ppm NAA exhibited highest dry matter accumulation/plant, yield attributes, seed yield(17.99 q/ha), net returns (Rs.27752.44/ha) and BCR (4.06) followed by 20 ppm NAA.Thus, seed inoculation with *Rhizobium*+ PSB along with foliar spray of 20 ppm NAA is better for realizing higher yield, net returns and profit in fenugreek.

Key words: Bio- fertilizers, Fenugreek, Plant growth regulators, Productivity, Profitability

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is an annual herbaceous multipurpose crop grown during winter season in North India. The seed is mainly used as condiment and in the pharmaceutical industry especially in preparation of ayurvedic medicines, while young plants are used as a vegetable and forage. Fenugreek is considered to have originated in South Eastern Europe and far West Asia, has been grown in India, part of North African counties, Argentina, France, Morocco, Lebanon. India is the one of major producer of fenugreek; its production is concentrated mainly in the state of Rajasthan, Madhya Pradesh, Maharashtra, Haryana, Punjab, Gujarat and Uttar Pradesh.The current productivity of fenugreek is 1005 kg ha^{-1}. In recent years, continued and imbalance application of chemical fertilizers with little or no use of organic manure is leading to poor nutrient use efficiency and low yield of crops. At the same time its increasing cost of production, changing trend towards increase environmental sensitivity and consumer's preference towards organic products are commonly realized now a days. Hence it has become important to search for other complementary resources and fertilizer of biological origin for integrated nutrient management in fenugreek. In this approach, microbial fertilization along with *Rhizobium* as well as phosphate solubilizing bacteria has been found promising to improve soil health and crop production. Phosphorus deficiency is usually the most important single factor which is responsible for poor yield of legume crops on all types of soil. In recent years, several strains of phosphate solubilizing bacteria (PSB) and fungi have been isolated which have shown to possess the ability to solubilise sparingly soluble phosphate, growth promotion and uptake of P by plants (Whitelaw 2000). Phosphatic

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bio- fertilizer is an important group of biological software containing some heterotypic bacteria and fungi which are known to have the ability to solubilise inorganic –P from insoluble sources by the production of organic acid. The mechanism of action of these microorganisms (PSM) involves secretion of organic acid, which lowers the pH and increase the availability of sparingly soluble phosphorus sources. The role of plants bio regulators in enhancing the production of crop has long been recognized and now this low cost technology has emerged as a boon for enhancing the agriculture production at an unprecedented rate. Plant hormones play important role as the small quantities, regulate the various physiological processes and balance the source and sink thereby increase the productivity. Gibberellins (GA_3) have been used in increasing stalk length and vegetative growth, flowers initiation, increasing fruit size, hastening maturity, improving fruit quality and controlling fruit cracking in horticultural crops GA_3 play an important role in enhancing the growth and yield in fenugreek (Badge *et al* 1993).The role of NAA in enhancing the fruit set, growth and yield attributes in fenugreek (Alagukannan and Vijay Kumar 1999). In the light of above cited facts, lack of information on these aspects with respect to fenugreek and considering the importance of fenugreek for human health and national economy. The present study was undertaken to find out the effect of bio-fertilizers and plant growth regulators on productivity and profitability of fenugreek.

MATERIALS AND METHODS

The field experiment on growth and yield of fenugreek as influenced by bio-fertilizers and plant growth regulators was conducted at National Research Centre on Seed Spices, Ajmer (Raj) during two consecutive *rabi* season of 2010-11 and 2011-12.The soil of the experimental site was sandy loam with pH 8.92 having 0.21 per cent organic carbon and 76.0, 33.4, and 234.1 kg/ha available N, P_2O_5 and K_2O respectively. The experiment was laid out in factorial random block design comprising of four levels of bio-fertilizers (no inoculation, *Rhizobium*, PSB and *Rhizobium*+ PSB) and four levels of plant growth regulators (GA_3 50 and 100 ppm and NAA 10 and 20 ppm) and water were sprayed thrice during the crop growth and development.The seed of variety Ajmer Methi-1 was sown keeping seed rate of 20 kg ha^{-1}. Recommended doses of fertilizers as well as other standard agro-techniques were used for raising good crop. 30 kg nitrogen,40 kg phosphorus and 20 kg potassium per ha were supplied through urea, DAP and muriatic of potash, respectively. Full dose of phosphorus, potash and half dose of nitrogen was applied as basal at the time of sowing and remaining nitrogen was given at 45 DAS. Spraying of PGRs was done three times by hand sprayer as per treatment- the first spray at 25 days after sowing, the second at 50% flowering and third spray at 20 days after 2nd spray was done to wet both sides of the leaves. Distilled water was sprayed on control plots. Seeds of fenugreek (variety Ajmer Methi-1) were treated with bio-fertilizer and after drying in the shade were sown at row to row spacing of 30 cm. Weeds are controlled by manual hand weeding as per need of the crop. Harvesting of the crop was done manually by pulling the dry plants out of the soil and removing the roots. In the study, fenugreek was evaluated for vegetative growth attributes, yield attributes and seed yield. Statistical analysis of data was done by standard procedure suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Bio-fertilizers: Perusal of data in (Table 1 and 2) reveals that bio-fertilizer significantly influenced the plant height at harvest, dry matter accumulation/ plant, number of branches / plant, number of nodules / plant, number of pods / plant, pod length, pod weight, number of seeds / pod , seed yield q/ha and straw yield. Seed inoculation with *Rhizobium* + PSB recorded the maximum plant height,dry matter accumulation/plant, number of branches / plant, number of nodules / plant, number of pods/ plant, pod length , pod weight, number of seeds/ pod, seed yield q/ha ,straw yield q/ha net returns and BCR respectively as compared to control. Phosphate solubilizing organisms have been reported to solubilise inorganic fixed form of P by excreting organic acids that directly dissolves fixed phosphatic materials of soil (Balchandran and Nagarajan 2002).These bacterial are also capable to secret some biologically active compounds such as auxin, gibberellins, vitamins etc. which are considered to be important for proper growth and development of

TABLE 1: Effect of bio-fertilizers and plant growth regulators on growth attributes of fenugreek

Treatments	Plant height (cm)	No. of	Dry matter accumulation/ plant (g)			No. of nodules
	At harvest	branches/ plant	60 DAS	90 DAS	At harvest	/plant
Bio-fertilizers						
Control	85.75	6.60	5.2	28.4	29.6	17.07
Rhizobium	86.45	6.67	5.9	33.6	33.1	21.13
PSB	85.79	6.61	5.9	33.5	33.3	20.20
Rhizobium + PSB	89.91	6.68	6.7	33.8	33.7	24.35
S.Em±	0.12	0.15	0.1	0.7	1.0	0.46
CD (P = 0.05)	0.33	0.44	0.3	2.0	3.0	1.31
Plant growth regulators						
Water spray	82.01	6.32	5.5	31.7	31.1	18.33
GA_3 50 ppm	89.27	6.75	6.2	32.3	32.6	20.33
GA_3 100 ppm	90.98	6.80	6.4	32.5	32.7	20.94
NAA 10 ppm	89.85	6.65	5.7	32.6	32.8	21.08
NAA 20 ppm	82.77	6.66	5.8	32.6	32.9	22.08
S.Em±	0.10	0.14	0.1	0.6	0.9	0.41
CD (P = 0.05)	0.30	0.39	0.3	1.8	2.7	1.18

TABLE 2: Effect of bio-fertilizers and plant growth regulators on yield attributes and seed yield of fenugreek

Treatments	Number of pods/ plant	Pod length (cm)	Pod weight (g)	Number of seeds/ pod	Test weight (gm)	Seed yield (q/ ha)	Straw yield (q/ ha)
Bio-fertilizers							
Control	76.55	11.40	4.53	16.99	15.19	13.89	42.62
Rhizobium	85.24	11.87	4.68	17.68	15.29	16.07	44.54
PSB	85.23	11.85	4.63	17.60	15.36	16.31	55.27
Rhizobium + PSB	89.62	12.05	4.72	17.81	15.60	17.43	46.68
S.Em±	1.84	0.28	0.11	0.38	0.13	0.24	0.88
CD (P = 0.05)	5.28	0.80	0.31	1.09	0.38	0.75	2.70
Plant growth regulators							
Water spray	80.03	11.58	4.29	17.06	15.06	13.36	39.31
GA_3 50 ppm	84.56	11.80	4.66	17.41	15.39	16.29	45.63
GA_3 100 ppm	84.89	11.62	4.68	17.45	15.62	16.59	46.45
NAA 10 ppm	84.97	11.86	4.71	17.68	15.36	17.65	46.78
NAA 20 ppm	86.37	12.12	4.85	18.00	15.36	17.99	47.48
S.Em±	1.65	0.25	0.10	0.34	0.12	0.21	1.10
CD (P = 0.05)	4.72	0.71	0.28	0.98	0.34	0.85	3.09

plant (Whitelaw 2000). The results corroborate with the findings of Shinde and Saraf (1992) in chickpea Yadav and Srivastava (1997) in gram. Thus, concomitant effect of *Rhizobium* and PSB inoculation led to the enhanced nitrogen and phosphorus availability which might have utilized by plants in synthesis of protein, carbohydrates, starch and its partitioning towards formation of flowers and increases in sink capacity both in size and numbers (Jat 2002), which seems to have improved yield attributes and consequently yield of the fenugreek crop. Similar beneficial effect of *Rhizobium* culture in fenugreek (Baboo and Sharma 1995. These findings are in agreement with those of Yadav and Srivastava (1997) in gram, Bothe *et al* (2000) in fenugreek.

Plant growth regulators: The results revealed that foliar application of plant growth regulators significantly improved the growth characters. Among different plant growth regulators applied, 100 ppm GA_3 resulted in the highest plant height, number of branches/plant followed by other treatments. It may be noted that irrespective of the concentration, GA_3 proved more effective in increasing the plant height than other treatments. The maximum dry matter accumulation /plant and number of nodules/plant were recorded in 20 ppm NAA followed by rest treatment (Table 1). The effectiveness of GA_3 to enhance the vegetative characteristics of fenugreek crop might be due to rapid cell elongation and division in growing portion of plants and increased uptake of

TABLE 3: Effect of bio-fertilizers and plant growth regulators on economics of fenugreek production

Treatments	Cost of cultivation (Rs/ha)	Gross return(Rs/ha)	Net return(Rs/ha)	BCR
Bio-fertilizers				
Control	1544.20	29851.30	18307.10	2.31
Rhizobium	11877.00	31917.49	20040.49	2.48
PSB	11681.00	31859.05	20178.05	2.49
Rhizobium + PSB	11701.00	33915.27	22214.27	2.71
S.Em±	-	965.21	561.39	0.08
CD (P = 0.05)	-	2762.91	1606.98	0.22
Water spray	6795.00	26230.55	19435.55	2.86
GA_3 50 ppm	14741.50	31282.48	16540.98	1.12
GA_3 100 ppm	23244.00	32638.81	9394.81	0.40
NAA 10 ppm	6839.50	34591.94	27752.44	4.06
NAA 20 ppm	6884.00	34685.11	27801.11	4.04
S.Em±	-	863.31	627.66	0.09
CD (P = 0.05)	-	2471.22	1796.66	0.25

nutrients. The characteristic property of NAA in delaying senescence process and retention of flower and fruits probably resulted in more dry matter accumulation per plant at later stage of plant growth (Kalita *et al* 1995). The results are in close conformity with findings of Deore and Bharud (1990) and Mishriky *et al* (1990) in fenugreek. Critical examination of data in (Table 3) revealed that foliar spray of plant growth regulators significantly increased the number of pods/plant, pod length, pod weight, number of seeds/pod, seed yield and straw yield q/ ha in comparison to control. Foliar application of 20 ppm NAA recorded the maximum number of pods/ plant, pod length, highest pod weight, number of seeds/pod, seed yield, straw yield q/ ha net returns and BCR which was closely followed by 10 ppm NAA. The overall improvement in plant growth by cell division, cell enlargement and production of sufficient photosynthesis through increased chlorophyll content of leaves on one hand and efficient utilization/immobilization photosynthesis towards development of flowers and fruits on the other hand, might have been responsible for increased yield attributes. Thus, remarkable improvement in different yield component along with seed yield of fenugreek crop primarily appears to be a function of greater photosynthetic efficiency per unit land area, maintenance of its higher rate for longer period, especially during post- flowering period and at the late pod filling stage leads to increase greater accumulation of dry matter which resulted in higher productivity of crop. Significant improvement in yield components and yield of fenugreek crop under the foliar application of plant growth regulators is in close accordance with the findings of Singh and Sharma (1996), Singh *et al* (1999), Sanna *et al* (2001) with NAA. Thus, foliar spray of NAA 20 ppm is the best treatment for realizing highest yield attributes and seed yield of fenugreek in comparison to rest treatment.

CONCLUSION

Thus seed inoculation with *Rhizobium* and PSB along with foliar spray of 20 ppm NAA is better for realizing higher yield, net returns and profit in fenugreek.

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